World J Surg (2016) 40:6–13
DOI 10.1007/s00268-015-3258-3

ORIGINAL SCIENTIFIC REPORT

Vital Statistics: Estimating Injury Mortality in Kigali, Rwanda

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Published online: 13 October 2015

Abstract

Background Globally, injury deaths largely occur in low- and middle-income countries. No estimates of injury-associated mortality exist in Rwanda. This study aimed to describe the patterns of injury-related deaths in Kigali, Rwanda using existing data sources.

Methods We created a database of all deaths reported by the main institutions providing emergency care in Kigali—four major hospitals, two divisions of the Rwanda National Police, and the National Emergency Medical Service—during 12 months (Jan–Dec 2012) and analyzed it for demographics, diagnoses, mechanism and type of injury, causes of death, and all-cause and cause-specific mortality rates.

Results There were 2682 deaths, 57 % in men, 67 % in adults >18 year, and 16 % in children <5 year. All-cause mortality rate was 236/100,000; 35 % (927) were due to probable surgical causes. Injury-related deaths occurred in 22 % (593/2682). The most common injury mechanism was road traffic crash (cause-specific mortality rate of 20/100,000). Nearly half of all injury deaths occurred in the prehospital setting (47 %, $n = 276$) and 49 % of injury deaths at the university hospital occurred within 24 h of arrival. Being injured increased the odds of dying in the prehospital setting by 2.7 times ($p < 0.0001$).

Conclusions Injuries account for 22 % of deaths in Kigali with road traffic crashes being the most common cause. Injury deaths occurred largely in the prehospital setting and within the first 24 h of hospital arrival suggesting the need for investment in emergency infrastructure. Accurate documentation of the cause of death would help policy-makers make data-driven resource allocation decisions.

This work has been presented in part at the US Investigators' Network Symposium on Global Non-Communicable Diseases Research, Emory University, Sept 2014 and at the College of Surgeons of East, Central, and South Africa Conference, Dar es Salaam, Tanzania, Dec 2014.

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Introduction

Injury accounts for 16 % of the global burden of disease [1]. More than five million people worldwide die from injury annually, and disability from injury affects an additional 20–50 million people each year [2, 3]. Poor people in low- and middle-income countries are particularly affected by trauma and bear an inequitable distribution of the burden of injury [4]. Ninety percent of road traffic injuries occur in these settings, and this burden is projected to increase as these countries rapidly urbanize and motorize without associated improvements in safe vehicle design, roads, and traffic safety enforcement [3]. Deaths from injury in East Africa increased by 51 % from 1990 to 2010 per the Global Burden of Disease 2010 study [5].

Despite this, few countries, particularly in sub-Saharan Africa, have collated data from existing systems to describe a comprehensive picture of injury [6, 7]. In Uganda, a methodical evaluation of the prehospital and hospital-based care show that 25 % of all deaths occurred due to injury, with road traffic crashes being the most common mechanism, in comparison to 7 % of deaths associated with injury in the United States [8, 9]. The odds of dying from injury in Kampala were four times than in the US and 53 % of injury-associated deaths occurred in the prehospital setting with police officers, taxi drivers, and local officials providing emergency aid [10, 11].

In Rwanda, efforts to determine the burden of injury across the country have included population-based household surveys and a hospital-based trauma registry [12–15]. However, few estimates of injury mortality exist. This project was designed by a multi-institutional collaborative as one step to understanding injury mortality in Kigali using existing data sources.

Materials and methods

Kigali (population 1,135,428, 2012 Census, National Institute of Statistics [16]), is the capital of Rwanda. An international collaboration of clinicians, hospital administrators, and researchers identified the main facilities providing emergency care in Kigali for this project, including the two Referral hospitals in the city—University Teaching Hospital-Kigali (UTH-K) and Rwanda Military Hospital (RMH), and two high-volume District Hospitals—Kibagabaga and Kacyiru Police Hospital. Prehospital emergencies are tracked by Service d'Aide Médicale d'Urgence (SAMU), which is the public emergency medical service in Kigali, as well as the Rwanda National Police. Both were additional data sources. Deaths occurring in the community that were not reported to one of these institutions were excluded due to lack of record-keeping at the community level.

In Rwanda's government hospitals, each clinical unit has unique data collection practices, with a centralized hospital-wide statistics office overlooking the process. Death certificates are issued at all the hospitals; however, it is quite common for the cause of death to be broadly categorized as "illness" or "sa maladie" by the staff who fear that writing the truth might provoke the family of the deceased. To have the most accurate information, we reviewed all ward log books and logs of death certificates across all data sources.

At three of the hospitals, we collected demographics, hospital admission and discharge dates, diagnosis, and survival status upon discharge. At Kacyiru Police Hospital, which houses Rwanda's only forensics medicine department and a morgue transport service, postmortem and transport records were reviewed. The Rwanda National Police logs and SAMU records were reviewed for demographics, date of death, cause of death, and mechanism of injury.

A de-identified dataset of all deaths captured by these institutions over 12 months (Jan–Dec 2012) was created in Microsoft Excel and duplicates were eliminated manually. Descriptive analysis was performed and all-cause mortality and cause-specific mortality were calculated based on the population of Kigali. We did not distinguish between patients who were from Kigali versus those referred to facilities in Kigali from elsewhere in the country. Causes of death were categorized as medical or surgical or unknown based on recorded diagnoses. The surgical deaths were categorized as traumatic or non-traumatic. The traumatic deaths were evaluated by mechanism of injury (blunt, penetrating, thermal, drowning, and other mechanisms), intention of injury (intentional or non-intentional cause), and body region affected (head, spine, abdomen, pelvis, and extremities).

Rwanda Biomedical Council Scientific Committee, UTH-K Ethics Committee and Partners Healthcare Institutional Review Board approvals were obtained prior to conduct of this project. Statistical analyses were performed using SAS 9.3 and Microsoft Excel software and z test and Student's t test were calculated with 95 % confidence intervals and a p value of 0.05 to establish statistical significance.

Results

Injury mortality in Kigali

There were 2682 deaths captured, which is an all-cause mortality rate of 236 per 100,000 people (Table 1). Cause of death was not known in 632 cases (23.6 %). A quarter of all deaths ($n = 682$, 25.4 %) occurred in the prehospital

Table 1 Overall characteristics of deaths in Kigali, Rwanda

	N	%
Total deaths	2682	
By source		
UTH-K	1572	58.6
Rwanda military hospital	271	10.1
Kibagabaga district hospital	426	15.9
Kacyiru police hospital	297	11.1
Police: CID	55	2.1
Police: traffic division	61	2.3
Sex		
Male	1538	57.3
Female	1068	39.8
Age		
0–4	432	16.1
5–18	178	6.6
>18	1796	67.0
Age unknown	276	10.3
Diagnosis		
Medical condition	1123	41.9
Surgical condition	927	34.6
Surgical: trauma	593	22.1
Surgical: non-trauma	305	11.4
Unk surgical	29	3.1
Diagnosis unknown	632	23.6
Mechanism		
Blunt	379	63.9
Fall	30	7.9
Road traffic crash	232	61.2
Unknown	14	3.7
Blunt force, assault or falling object	77	20.3
Landslide/earthquake	32	8.4
Penetrating	21	3.5
Firearm	11	52.4
Stab	4	19.0
Drowning/burn/other	96	16.2
Drown	30	5.1
Other	30	5.1
Thermal	34	5.7
Unknown trauma	97	16.4
Total injury deaths	593	
Intention of injury deaths		
Unintentional	355	59.9
Intentional	110	18.5
Unknown	132	22.3
Total injury deaths	593	

UTH-K University Teaching Hospital-Kigali, *CID* criminal investigation division, Proportions reflect each category except where indicated

Table 2 Injury deaths by setting in Kigali

Type and location of deaths	%	*N*
Total deaths		2682
Prehospital deaths	25.4 %	682
Injury	40.5 %	276
Noninjury	59.5 %	406
Hospital deaths	74.6 %	2000
Injury	15.9 %	317
Noninjury	63.3 %	1266
unknown	20.9 %	417
Injury deaths	22.1 %	593
Hospital deaths	53.5 %	317
Prehospital deaths	46.5 %	276
Noninjury deaths	77.9 %	2089
Hospital deaths	60.6 %	1266
Prehospital deaths	19.4 %	406
Odds of dying from injury in prehospital setting	2.71*	2.3–3.3 (95 % CI)

* $p < 0.0001$

setting. When deaths were categorized as medical (42 %, $n = 1123$), surgical (34 %, $n = 927$), or other, 593 were injury-related accounting of 22 % of all deaths in this study. Injury-specific mortality rate was 52 per 100,000. The most common injury mechanism was blunt trauma from road traffic crash with a cause-specific mortality rate of 20 per 100,000. Of all injury deaths, 47 % occurred in the prehospital setting ($n = 276$). Only 16 % of all deaths in the hospital setting were from injury although 23.6 % did not have adequate cause of death recorded at the hospital level. The odds of dying in the prehospital setting if injured is 2.7 times ($p < 0.0001$) compared to being uninjured (Table 2).

Mortality by source

University teaching hospital Kigali

A total of 1572 deaths were captured; 215 were dead on arrival (13.6 %). Cause of death was medical in 53 % ($n = 834$) and surgical in 39 % ($n = 620$), although 7.5 % did not have a cause of death recorded. Of the 620 surgical deaths, 53.0 % ($n = 326$) were injury-related which is 21 % of all deaths at this site. The majority of injury deaths occurred in adults ($n = 236$, 72 %), largely in men ($n = 240$, 74 %), and with a median age of 28 years (range 0–91 year).

Head injury was the most common diagnosis recorded in injury deaths (58 %, $n = 192$) (Table 3). Road traffic

Table 3 Trauma diagnoses implicated in injury deaths at UTH-K

Diagnoses	*N*	%
Head injury	192	58.9
Other/unknown trauma	42	12.9
Burn	23	7.1
Spinal/neck injury	16	4.9
Chest injury	11	3.4
Intoxication/poisoning	10	3.1
Drowning	8	2.5
Lower extremity fracture	8	2.5
Abdominal injury	7	2.1
Pelvic injury	7	2.1
Animal/insect bite	2	0.6
Total injury deaths	326	

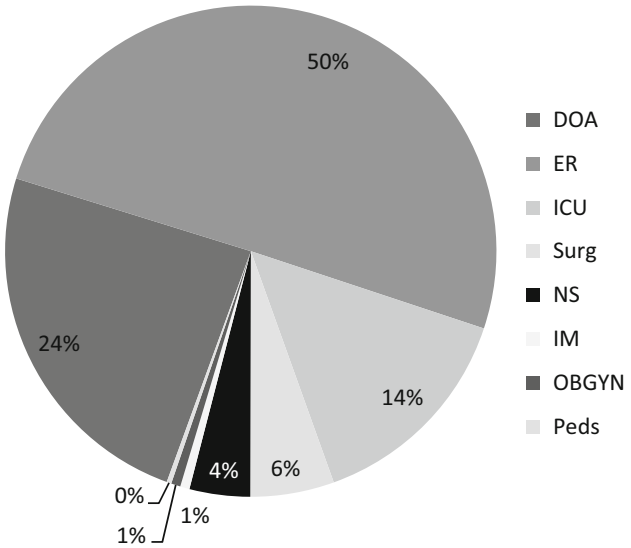

Fig. 1 Location of injury-related deaths at UTH-K. *DOA* dead on arrival, *ER* emergency room, *ICU* intensive care unit, *Surg* surgery ward, *NS* neurosurgery ward, *IM* internal medicine ward, *OBGYN* obstetrics/gynecology ward, *Peds* pediatric ward

injury was the most common mechanism (125 of 326 deaths, 38 %). In children <5 years, head injury ($n = 10$, 43 %) and burns ($n = 9$, 39 %) were the most common mechanisms accounting for 83 % of all injury deaths, although medical causes and prematurity accounted for 70 % of all under-five deaths (n = 194) at this hospital.

Of the 326 injury deaths recorded at UTH-K, 24 % ($n = 79$) were dead on arrival to the hospital, and 247 deaths occurred at the hospital, of which 66 % ($n = 164$) occurred in the emergency department. Most of these deaths ($n = 121$) occurred within 24 h of presentation to the hospital (Fig. 1).

Rwanda military hospital

A total of 271 deaths were captured; 192 (71 %) were dead on arrival. The cause of death was medical ($n = 90$, 33 %), surgical ($n = 98$, 36 %), or unknown ($n = 83$, 31 %). Of the surgical deaths, trauma was the main cause ($n = 77$, 79 %). The majority of injury deaths occurred in adults ($n = 141$, 52 %) although age was not recorded in 44 % ($n = 118$). Injury deaths were mostly in men ($n = 64$, 77 %) and the mean age of injury death was significantly lower than the mean age of all deaths at RMH (32 vs. 46 years, $p = 0.000683$).

Road traffic injury was the most common mechanism of injury-related deaths (37/77, 48 %). More assault and firearm-related deaths were reported at this facility than the other sites ($n = 21$, 27 %) although unintentional trauma still predominated as the major cause of injury death ($n = 50$, 65 %).

Kibagabaga district hospital

There were 426 deaths captured and minimal details were recorded for all. Deaths in men predominated ($n = 232$, 54 %). The median age was 31 years with the majority of deaths occurring in adults ($n = 269$, 63 %) followed by deaths in children under 5 years ($n = 86$, 20 %). Deaths were recorded in Emergency ($n = 138$, 32 %), Internal Medicine Male ward ($n = 86$, 20 %), Internal Medicine Female ward ($n = 74$, 17 %), and Maternity ($n = 61$, 14 %). Only 12 deaths were reported in the surgery ward for the entire duration (2.8 %). Cause of death, diagnosis, and mechanism were not recorded for any death.

Kacyiru police hospital

There were 297 deaths captured. Of all deaths, 59 % ($n = 176$) underwent postmortem exam. Most deaths occurred in men ($n = 182$, 61 %), with a mean age of 33.8 years (median 30 years). When cause of death was reported, injury was the most common cause ($n = 84$, 67 %), although cause of death was not available in 168 (58 %). When injury mechanisms could be further studied, blunt mechanism was implicated in 49 % with intent to harm in 61 %.

Service d'aide médicale d'urgence (SAMU)

Of the patients transported by SAMU, there were six pre-hospital deaths enroute to UTH-K and were taken into account in analyses from that site. SAMU does not capture on-scene deaths.

Traffic police

There were 63 crashes involving 80 vehicles, resulting in 61 deaths on scene and two more deaths at UTH-K. Deaths occurred mostly in men (83 %) with a median age of 25 years. Adults over 18 years accounted for 57 % (36/63). Crashes occurred under optimal conditions. Motorcycles were most frequently involved ($n = 32$, 40 %) (Fig. 2). Pedestrians died most commonly (25/63, 40 %) (Fig. 3).

Criminal investigation division

There were 55 deaths captured. Deaths occurred in women in 19 cases (35 %) and in men in 21 cases (38 %) although sex was not recorded in 27 % ($n = 15$). Median age of death was 23 years. Adults accounted for 45 % of the deaths but age was not reported in 31 % ($n = 17$). The majority of the cases ($n = 45$, 82 %) involved trauma, although mechanism was not recorded in 9 cases (16 %). Deaths were intentional in 40 cases (85 %), and of these assault/homicide was the most common (53 %, $n = 29$).

Discussion

Injuries accounted for 22 % of all deaths in this study. Many deaths from injury occur outside the hospital and during the initial 24 h in hospital suggesting that injuries may be of high acuity and immediate access to high-quality emergency care is limited.

Injury mortality results from this study are consistent with estimates from the Global Burden of Disease 2010 study that reports a road traffic injury mortality rate of 20 deaths per 100,000 people in this region, which is substantially higher than in the United States [5]. More specifically, deaths from injury in Rwanda parallel published reports from Uganda which reveal that approximately 25 % of all deaths are from injury in that country compared to 22 % in Rwanda. Head injury was also the most common cause of death in our study (58 %) as in Uganda (55–65 %) and Tanzania (52 %), although more so than in the US (25 %) [8, 17] [18]. In Kigali, 45 % of injury deaths occurred in the prehospital setting compared to 53 % in Kampala [8].

Our findings suggest many areas for improvement. At this time, there is no vital registration system to track the actual number of deaths in the country. Standardized mortality data collection would produce high-quality data for evidence-based decision-making as encouraged by the Lancet Commission on Global Surgery and others [19–21]. The WHO International cause of death certificate could be useful across facilities in Rwanda and incorporating it into the standard patient chart could encourage its use. Training in vital statistics and injury surveillance needs to be supported so that death certificates may be accurately recorded and so that official records indicate more than "sa maladie" [22]. Further investment in rigorous prehospital care to prevent delays in access to emergency surgical care is essential and feasible [11, 19]. Training of prehospital emergency staff could improve secondary injury prevention and outcomes. Education regarding public safety could improve primary prevention of deadly injuries. Finally, there is a great need for postmortem capabilities in this region to inform the cause and mechanism of these deaths [23].

At the referral hospital level, since 74 % of injury deaths at UTH-K happened in the Emergency ward and within 24 h of patient arrival, the initial assessment of injured patients may need to be more efficient in identifying and treating injured patients who are at immediate risk of death. A recently implemented triage system may address this and is being evaluated by SidHARTe—a collaboration between the Rwandan and Ghanaian governments and Columbia University [24]. Head injury was the most common cause of injury death at UTH-K. Clinical Practice Guidelines are now being developed to standardize the management of traumatic brain injury patients. At RMH, demographics and cause of death were not recorded in many cases. Furthermore, the majority of deaths happened at other sites, suggesting that referring health centers need better support to stabilize patients before transfer to RMH and that more investment in prehospital care could also support care delivery en route from these centers to RMH.

At the district hospital level, records often lacked basic information such as age, diagnosis, mechanism, and cause of death even though most deaths occurred within the hospital. Little information regarding injury deaths can be determined from the current records at Kibagabaga Hospital. The majority of deaths recorded at this site occurred in the emergency and internal medicine wards, which suggests that rapid identification of critically ill patients in the emergency ward could be improved. A triage system, such as one implemented at UTH-K, might be beneficial at this level of the health system. The availability of postmortem examinations at this facility resulted in more detailed cause and mechanism of death data and should continue to be supported by the government.

The majority of road traffic deaths recorded by the Traffic Police involved pedestrians and motorcycles or trucks suggesting that pedestrian movement is a high risk and unsafe activity. The on-scene deaths suggest that these crashes result in severe injury which may not be treatable. Furthermore, the majority of deaths recorded by the Traffic Police happened during optimal weather and road conditions. It is possible during good weather that more people are on the road but do not have safe places to walk. It may

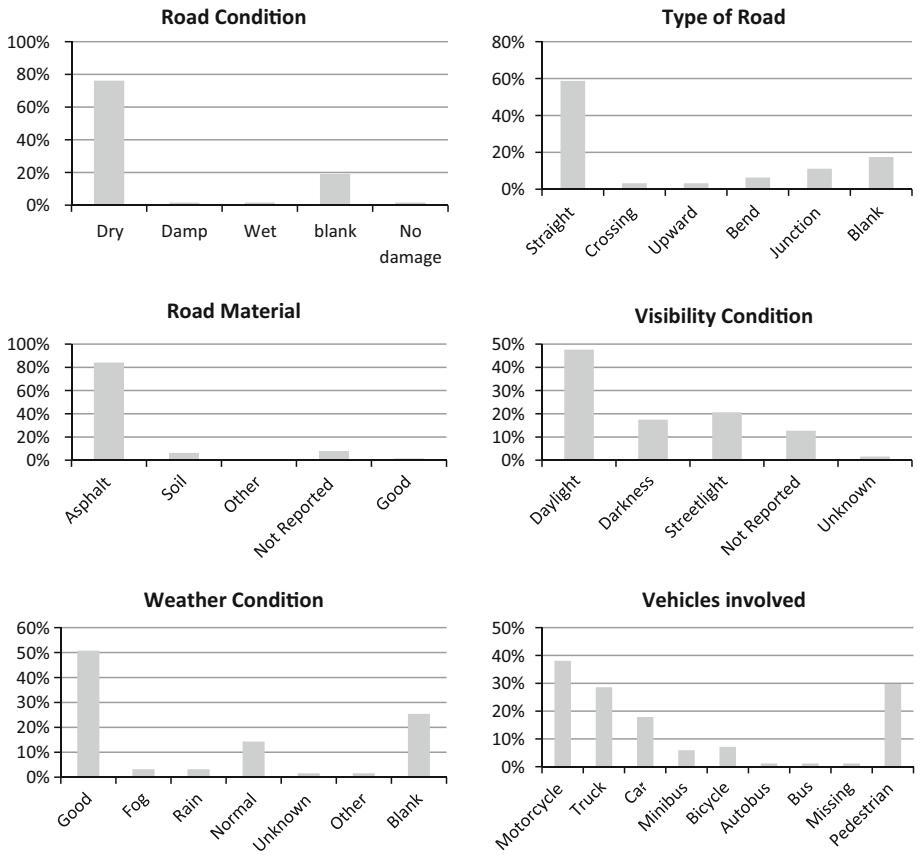

Fig. 2 Crash conditions in on-scene deaths

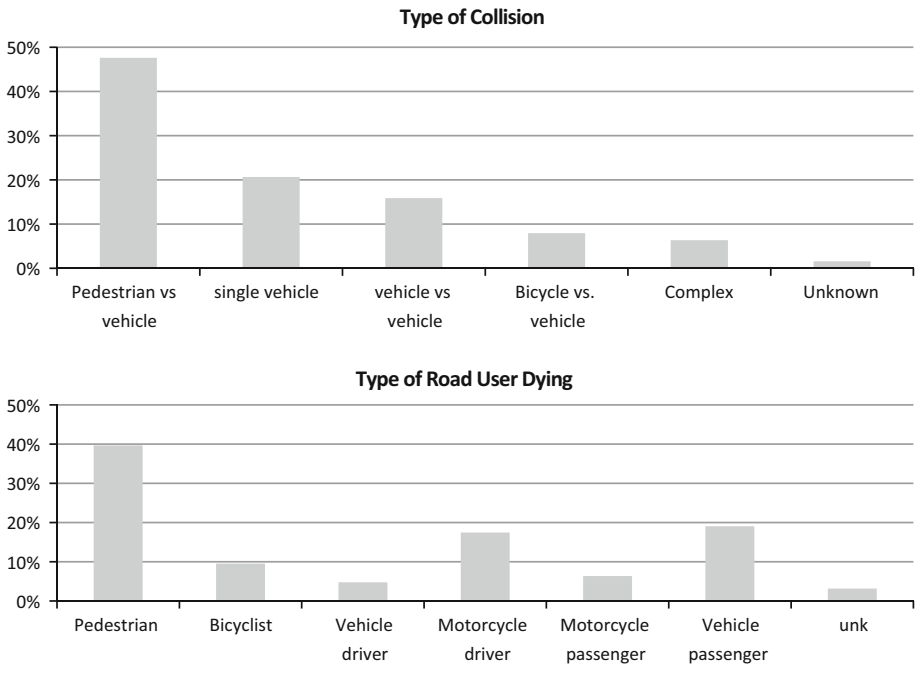

Fig. 3 Collision type and road users affected

also be possible that during good weather and on good roads, people in vehicles are willing to take more risks, such as speeding or disregarding traffic rules/regulations, at a time when more pedestrians are on the road. Thus, more crosswalks and sidewalks and strict enforcement of traffic rules and regulations may be the useful next steps. Built environmental analysis may be a useful tool to identify and address high-risk roadways in Kigali. While the database of road traffic deaths tracked by the Police includes environmental risk factors, it does not contain information on prehospital medical management, transfers to referral hospital, or use of SAMU services, which should be considered in the future. Homicide and suicide seemed to account for a small portion of the deaths in Kigali as recorded by the Criminal Investigation Division although some of the details such as age were not consistently captured.

Our study has many limitations. Not all of the hospitals in Kigali were included in this project, and therefore we may be underestimating the total number of deaths related to emergencies in the city. However, study stakeholders took care to carefully identify the predominant sites providing emergency care in the city. Multiple databases exist in various settings which collect different sets of information, use non-standard methodology to attribute causes of death and collect inadequate detail: 23.6 % of deaths in our study had no cause of death recorded. We therefore could not retrospectively determine the accuracy of the cause of death reported at the sites. Lastly, this study provides a snapshot of mortality statistics; it does not display trends over time.

In conclusion, injuries, especially road traffic crashes, account for a significant burden of deaths in Kigali. Many deaths from injury occur outside the hospital and during the initial 24 h in hospital. Investing in better emergency infrastructure to provide early and life-saving interventions may be more likely to avert mortality in young, economically productive Rwandans. Accurate documentation of the cause of death would help policy-makers make data-driven resource allocation decisions. An injury surveillance system that allows outcomes to be tracked would be invaluable.

Acknowledgments We would like to thank the hospitals' administrative leaders; Department chairmen and head nurses of all the hospital wards, data analysts of the hospital statistics offices, and hospital morgue officers contributing to this study. We are also grateful for assistance and the vision of the Rwanda National Police, particularly the Commissioners of Traffic Police and Criminal Investigation Division and their staff who understood and supported this project from the outset.

Funding Dr Jayaraman was sponsored by the Harvard Medical School Health Disparities Fellowship and by Brigham and Women's Hospital where she was a Clinical Instructor in Surgery at the time this project was developed, funded, and conducted. Ms. Kim was a medical student at Emory University School of Medicine and was sponsored by Emory School of Medicine and Emory Global Health Institute when she conducted this project.

Compliance with ethical standards

Conflict of interest None.

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